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ABSTRACT

This report for the National Academy of Engineering's Office of Public Awareness represents the second phase of an examination of public opinion about engineering and technology. This document presents an analysis of six qualitative, focused group discussions or focus groups. Five of these groups were college educated Americans and one was comprised of selected legislative assistants and committee staff from both the United States Senate and the House of Representatives. The research analyzed in this report looked at several areas. These included: (1) views about engineers and the engineering profession, including what the respondents think engineers do; (2) views about the personality and character of those in the engineering profession; (3) the perceived differences between engineers and scientists; (4) views about the impact of technology on the respondents' lives; (5) views about technology's negative effects, including risks and job loss; and (6) issues relating to technology and decision making in the Congress. The document examines 22 hypotheses related to the above areas, and presents an analysis of each. (TW)

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ENGINEERING AND TECHNOLOGY: THE PUBLIC'S PERSPECTIVE

PART 2
A Qualitative Analysis for The National Academy of Engineering

1986

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ENGINEERING AND TECHNOLOGY: THE PUBLIC'S PERSPECTIVE

A Qualitative Analysis for
The National Academy of Engineering
by
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INTRODUCTION

This report for the National Academy of Engineering's Office of Public Awareness presents an analysis of a series of six qualitative, focused group discussions or focus groups: five with college educated Americans and one with selected legislative assistants and committee staff from both the U.S. Senate and House of Representatives. The report represents the second phase of an examination of public opinion prepared by the Public Agenda Foundation for the Academy; it takes off from an analysis by Public Agenda of the survey data collected over the previous fifteen years by various public opinion firms. (See "Public Attitudes Toward Engineering: An analysis of existing survey data" by Mary Komarnicki and John Doble, The Public Agenda Foundation, February, 1986.) Together, these works provide the Academy with a comprehensive, quantitative, historical analysis along with a current, qualitative assessment of Americans' thinking about engineering and the impact of technology on society.

Before presenting the results, a word about methodology is in order. The kind of qualitative research represented by focus groups has, by definition, particular strengths and weaknesses as a methodology: interviews are conducted at length and in great depth, and an investigator's initial assumptions and suppositions are often challenged, modified or totally changed by respondents' comments; the data are particularly rich and vivid since respondents describe at length <u>how</u> they feel and <u>why</u> they hold the views they do. However, since the samples used in focus group research are small and stratified instead of large and random, generalizations within a measurable sampling error cannot be drawn from focus groups or any other method that generates qualitative results. Optimally, qualitative research is used as a precursor to a national probability survey, with the former serving to generate "hypotheses" and the later used to test or validate them. In this report, therefore, the analysis, observations and interpretations of this phase of the research are described as hypotheses rather than as "conclusions."

The research focused on two main areas:

1. The views of college educated Americans about engineers and the profession of engineering, including what these respondents think engineers do; their views about the personality and character of those in the profession; the difference, if any, between college educated Americans' views about engineers and scientists, and about engineering and science; and what role these people think engineers should have in terms of public policy as it relates to technology.

2. The views of college educated Americans about the impact of technology on their own lives and on society as a whole, with particular emphasis on their views about technology's perceived negative effects, including risks and job loss.

Additionally, we interviewed a group of legislative and committee leaders from Capitol Hill about issues relating to technology and decisionmaking in the Congress, and investigated their thinking about many similar issues. In this report, we frequently compare and contrast the responses of these key leaders to the views of the public.

The areas for examination and particular lines of questioning were developed on the basis of the Public Agenda's analysis of survey data completed in the first phase of the project, referenced above. That volume served to spotlight particularly interesting topics for detailed investigation.

The Public Agenda would like to acknowledge the contributions to this effort made by several officials and individuals associated with the Academy. In completing this research, the Public Agenda worked in close collaboration and consultation with key officials at the National Academy of Engineering. Particularly important contributions to the project's conceptualization and execution were made by Hugh Miller, Bert Vorchheimer and Isaac Auerbach. Throughout the effort, the Public Agenda worked closely with the Academy's

Director of the Office of Public Awareness, Mr. Bradley Ziff. In addition to observing each of the sessions, Mr. Ziff assisted us in developing a framework for the research, provided professional reactions to respondents' comments, and guidance in the development of particular lines of questioning for each session. Since the goal of the effort was to investigate citizens' thinking about issues closest to the Academy's interests, needs and goals, Mr. Ziff's advice and consultation were invaluable. His substantive contributions to the effort, from design to execution, were thoughtful, good humored, and, indeed, essential to the success of the project.

The authors would also like to acknowledge the research effort and significant contribution to this report by Ms. Judith Kallick of the Public Agenda. Finally, we would like to thank Public Agenda's Executive Director, Robert J. Kingston, for reviewing and commenting on this report, and for his help, support and overall leadership throughout both phases of this project.

II. EXECUTIVE SUMMARY

The following Executive Summary lists the twenty-two hypotheses presented in this report. Following each one is a brief elaboration of some of the more important interpretive observations and implications. The data are presented so that readers with particular needs can review those areas of greatest interest first. The hypotheses are divided into two main sections: those relating to Americans' views about engineers and the profession of engineering, and those related to Americans' and legislative leaders' thinking about the development and use of new technology, and their assessments of technology's social impact.

Summary of Part I: Americans' Views About Engineers and Engineering

Hypothesis #1: Americans know very little about the profession of engineering or about what engineers do. To most people, engineering is virtually an "invisible profession."

Other than broad generalizations such as engineers "build bridges and highways," or engineers "design automobiles, aircraft and nuclear power plants," most respondents found it hard to detail exactly what engineers do or what the profession involves.

Hypothesis #2: Americans have only a dim sense of how engineering affects their lives. Most people take engineering for granted, without considering the profession's responsibility for technological innovation.

Rather than engineers, respondents were most likely to say scientists, inventors or "technicians" were responsible for technological innovation, and that professionals associated with particular fields were responsible for innovations in various areas; for example, respondents said that doctors were "responsible" for technological innovations related to medicine.

Hypothesis =3: The profession is visible to most Americans only in cases of technological mishaps, failures or breakdowns.

Attitudes about auto industry engineering suggest that Americans spontaneously consider the role of engineering only in cases of technological breakdowns, failures or accidents. Most people do not think about the profession as long as things run smoothly. In this sense, the profession may be in dangerously ambivalent circumstances: the American people want and expect the profession to meet a standard of excellence and take engineering for granted as long as that standard is met; and most people spontaneously consider the role of engineering only when something goes wrong.

Hypothesis =4: Americans have trouble distinguishing between engineering and science, and see many similarities in the kinds of people in each profession.

Most respondents found it hard to articulate the difference between science and engineering, and a number of the college educated Americans interviewed said that engineering was merely one of the many branches of science, similar to biology, chemistry or physics. Additionally, many said that members of the two professions had a great deal in common in terms of their personality, interests, and aptitude.

Hypothesis =5: Compared to the fields themselves, Americans are able to draw numerous distinctions between individuals in the professions of science and engineering.

Respondents were able to draw a number of distinctions between members of the two professions. Most frequently, respondents said that scientists work at an abstract level while an engineer's work is more concrete, or that scientists come up with ideas while engineers figure out how to implement those ideas or make them work. Interestingly, respondents also said they would prefer a child or loved one to marry an engineer rather than a scientist, in part because engineers were said to be more practical and realistic.

Hypothesis #6: Americans have a number of negative views about stereotypical engineers.

The most frequently mentioned negatives stereotypes about a "typical" engineer involved what respondents called engineers' "inability to communicate" with those who are not members of the profession, or engineers' "poor social skills." Many also expressed the view that most engineers make poor managers.

Hypothesis #7: In spite of such negative stereotypes, most Americans see engineering as a desirable career. People feel that it is an esteemed profession with a good salary and good advancement opportunities.

In spite of their lack of detailed knowledge about the profession and the negative stereotypes that were widely held, the college educated Americans interviewed had quite definite ideas about the status of engineering. Virtually everyone interviewed regarded engineering quite highly, and said it was about on a par with medicine and law. People said engineers are well paid and have numerous job opportunities and good chances for advancement. Most respondents also felt that the profession was wide open for women and members of minority groups, and said they would be happy if a child or loved one decided to study engineering in college or make it a career.

Hypothesis #8: Except for engineers in the automobile industry and with the possible exception of the Japanese, U.S. engineers are felt to be the best in the world. Problems with industrial competitiveness are felt to be caused by management practices and employee attitudes, not poor engineering.

Respondents generally felt that U.S. engineering is the best in the world and therefore does not contribute to this country's problems with industrial competitiveness. In terms of education, U.S. colleges and universities that specialize in training engineers were felt to be the finest

that exist. However, a minority did feel that Japanese engineering was superior, and many said that Japanese engineers were a close second. Many people said American-made cars were "poorly engineered" and rated automobile industry engineering much lower than any other branch of the profession.

Hypothesis #9: The belief that American-made autos are "poorly engineered" has undermined public confidence in auto engineering even though most say auto industry engineers are not responsible for the problem. In fact, this perception has the potential to undermine Americans' confidence in the entire profession.

A conspicuous exception to the excellent rating respondents gave to U.S. engineering was the view that auto industry engineering is poor because of what is felt to be consistently poor product quality. While probing revealed that this low rating actually reflected respondents' views about industry management and workmanship, the difference in the rating for auto engineers and those in others fields was dramatic. The result suggests that even when the engineers involved are not felt to be responsible, industries or products where quality is felt to be low may create a "negative halo" that can undermine public confidence not only in those directly involved but in the entire profession.

Hypothesis #10: Americans believe that engineers have an unusually high degree of integrity.

Since engineering was seen as a field where answers are "exact" mathematical calculations and therefore either right or wrong, respondents said engineers were accurate, reliable reporters of their work; in this regard, engineers were felt to be more like accountants than, for example, attorneys whose professional opinions are matters of judgment. Respondents also said that the field's professional standards reinforce an engineer's sense of integrity since competence in determined on the basis of accuracy.

Hypothesis #11: Americans do not tend to blame engineers for technological accidents, mishaps or disasters.

Respondents were asked who was responsible for accidents such as Three Mile Island, Bhopal, problems with the Pinto fuel tank, airplane crashes where an engine falls off, and highway or bridge collapses. With near unanimity, respondents said engineers were not to blame for these mishaps; rather, management "shortcuts," human error, or poor maintenance were said to be the cause. One session was conducted after the fire at the nuclear power plant at Chernobyl; in that group, respondents said that even in that case, the Soviet engineers were not responsible for the accident. Another important result from that group was that the accident seemed to have little or no effect on respondents' views about the use of nuclear power.

Hypothesis #12: More specifically, Americans feel that the investigation into the Challenger accident showed that the engineers involved were not at all to blame.

Respondents felt that the engineers who testified before the Rogers Committee had acquitted themselves honorably and had conclusively shown that they were not to blame for the tragedy. However, some felt that the engineers involved should have more forcefully expressed their reservations and concerns about the decision to launch.

Hypothesis #13: Americans feel that engineers and scientists should be more involved in making decisions about the development of new technology. However, people do not feel that experts should have the final say.

Respondents felt that decisionmakers in government and industry should hear more directly from experts such as engineers and scientists about the potential costs, risks and benefits of developing or using new or potentially dangerous technologies.

Summary of Part II: Americans' and Legislative Leaders' Views About Technology

Hypothesis #14: Americans have great faith in technology, and feel that it has led to far more good than harm. Nonetheless, many worry about the rate of change.

With virtual unanimity, those interviewed said the U.S. must continue to develop new technology, that technology has improved our standard of living, and that technology is virtually synonymous with progress. However, respondents were concerned about the rate of technological change.

Hypothesis #15: Americans are also concerned about technology leading to job loss, especially for older workers.

Some respondents felt that job loss due to technological innovation had only begun and would become much more widespread and affect many more people in the foreseeable future than it does now. Numerous respondents expressed particular concern about older workers who would be too old to be easily retrained.

Hypothesis #16: Americans' faith in technology is neither blind nor without qualification: most feel that technology has created a number of serious problems.

Respondents saw various negative effects from the development and use of new technology, including depersonalization, computer errors, and the potential for loss of privacy.

Hypothesis #17: The key to solving many of these problems caused by technology is, in Americans' view, to develop more technology -- but with additional safeguards.

In spite of the perception that technology creates problems, the people interviewed felt that a key to solving such problems lies in the development of even more technology. However, many respondents said additional safeguards were necessary before developing or using potentially dangerous new technologies.

Hypothesis #18: Especially when expert opinion is divided, legislative leaders are concerned about how to regulate and decide about the development or use of expensive, complex technology that may pose risks to society.

Leaders described the difficulty of deciding about important technological issues when expert opinion is split, and several implied that such cases, members of Congress are more likely to disregard expert opinion altogether and look to other factors such as the wishes of their constituency.

Hypothesis #19: Contrary to leaders' assumptions, Americans define "new technology" in terms of computers, VCRs, and other work or household-related innovations rather than as technologies that are subjects of controversy.

Leaders' apparent misunderstanding of what the term "new technology" means to most Americans may lead them to incorrectly assess public opinion in this area. Based on the assumption that "technology" did not mean VCRs, etc., several leaders drew conclusions about how Americans feel about technology and technological development that were at odds with respondents' comments in the group sessions.

Hypothesis #20: Legislative leaders see SDI and job displacement as the biggest technological issues facing the U.S., but the public is most concerned about the impact of technology on people's daily lives.

Many leaders said the biggest technological issue facing us in the foreseeable future was development of SDI. However, the citizens did not mention SDI in this regard -- a result suggesting that most Americans are not aware of SDI or concerned about its economic impact. These results suggest that SDI's impact as a political issue has yet to surface and be felt.

Hypothesis #21: Leaders worry about America's technological competitiveness and overall technological literacy. While the public feels that U.S. engineering is the world's best, leaders express concern about policies affecting the future.

Citizens felt that U.S. engineers were the best in the world, that their education and training was superior, and that their overall level of competence was unmatched, except perhaps by the Japanese. Without disputing this view, many legislative leaders expressed concern about policies that they felt would hamper U.S. technological competitiveness in the future.

Hypothesis #22: Legislative leaders feel that increasing the public's level of 'technological literacy' would have a significant impact on the Congress.

Many legislative leaders said that, in general, Americans' views about developing and using new technology are balanced and reasonable. However, some said there are segments of the public who are not knowledgeable yet have a disproportionate effect on Congressional decisionmaking. In addition, many leaders felt that a more technologically literate public would lead to a more technologically literate Congress.

Implications of the Study for the National Academy of Engineering

Below we detail some of the more important implications of this research for the National Academy's efforts and programs, and for the engineering community as a whole. Following each section, we outline possible future endeavors that the Academy might consider in view of the research results.

I. The status of the profession

-- Americans believe that U.S. engineering is the best in the world. Americans want and expect the profession to meet a standard of excellence; as long as that standard is met, engineering is "invisible" to most Americans.

-- Americans spontaneously consider the role of engineering only in cases of technological failure.

An initiative to expand public awareness of the profession will help Americans see the critical role engineering plays in the development of new technology, and the impact of engineering on their lives.

II. The effect of a "negative halo"

-- Americans take for granted the technological accomplishments of engineering; the profession becomes visible to most people only when technology does not work or is felt to be of consistently low quality.

-- In such cases (e.g., with the design of American-made automobiles), Americans' initial reaction is to blame poor engineering; however, their considered view is that factors such as shortsighted management or lax workmanship are the real causes of what they perceive to be consistently poor product quality.

-- As future technology becomes more complex and its use becomes more widespread, breakdowns of various sorts will be inevitable.

-- Yet even when the engineers involved are not felt to be responsible, the public's generally positive views about engineering can be overwhelmed by perceptions of failure or poor quality.
-- In fact, such views can lead to the creation of a "negative halo" that has the potential to undermine public confidence in the entire profession.

An initiative to expand public awareness about the positive effects of engineering as well as of the profession's different branches and the role of management, political considerations and other factors in technological development will help create a buffer for the profession when technology is perceived to fail or cause serious social problems.

III. The role of the engineering community in decisionmaking about the use and development of new technology

--The public does not "blame" the engineers involved for the fate of the Challenger or even the accident at Chernobyl.
-- Largely because of perceptions about competence and integrity, the public feels that the engineering community should have a greater role in advising management about the use of potentially dangerous technology.
-- Americans also feel that decisionmakers in government and the Congress should hear more directly from members of the engineering community about the development or use of potentially dangerous technology such as nuclear power and the space shuttle.
-- Americans believe that increasing such "expert" involvement would significantly reduce the chances of accident and mishap.

Enhancing the advisory role of technical experts and other members of the engineering community to both private and government decisionmakers about issues involving the development and use of potentially dangerous technology would be strongly supported by the American people.

IV. Technological literacy and the risks of developing new technology

--Americans' general level of "technological literacy" is quite low.
-- Yet people generally have a balanced, realistic view of the potential risks and benefits of developing or using new technology.
-- The public's knowledge therefore may be consistently underestimated by policymakers who do not realize the depth and breadth of Americans' commitment to developing even potentially dangerous new technologies.
-- But the low level of technological "literacy" may affect certain people's acceptance of new technologies, especially older Americans.

Efforts to increase Americans' "technological literacy" may lead to greater acceptance of new technologies. Also, efforts to inform governmental decisionmakers about Americans' commitment to developing new technology and their willingness to accept risks will enhance their understanding of the public's views.

V. Congress, the public and America's industrial competitiveness

-- While Americans are deeply concerned about the nation's industrial competitiveness, they do not see a link between engineering, technology and this issue. Rather, people feel that such problems are caused by management, labor and other factors -- but not engineering.
-- Leaders say the future competitive position of the U.S. depends on technological development, and fear that inadequate investment in science, engineering and technological education at the secondary and university level, for example, will harm our ability to compete.
-- While many Americans favor greater investment in these areas, their failure to see the link between technology and industrial competitiveness makes this an issue of low salience.

An initiative to increase public understanding of the relationship between technology and America's future industrial competitiveness can help establish a national consensus to assist our policymakers in dealing with this issue.

III. HYPOTHESES: AMERICANS' VIEWS ABOUT ENGINEERS

Hypothesis #1: Americans know very little about the profession of engineering or about what engineers do. To most people, engineering is virtually an "invisible profession."

The college educated Americans interviewed for the project had only the most hazy, general ideas about the profession of engineering. In contrast to medicine or law, for example, about which respondents knew a great deal, engineering was a profession about which most people interviewed were only vaguely aware and had the most limited knowledge. While many respondents knew there are different branches in the profession and while some could even name several of them, most of those interviewed found it difficult to describe exactly what various branches of engineering involve or what different types of engineers do on a day-to-day basis. Other than broad generalizations such as engineers "build bridges or highways," or engineers "design automobiles, aircraft and nuclear power plants," most found it hard to provide much detail. For example, when asked to describe what an engineer does, a woman from Dallas said, "Engineers understand how machines can work for people" A Detroit man said that engineers "seek solutions to a problem." Another woman said engineers "make something (such as an assembly line) work for the lowest possible cost."

Respondents also did not know the name of any famous engineers. When asked the occupation of men such as Edison, Henry Ford or Benjamin Franklin, most said these men were inventors or in fields other than engineering. A Dallas man said they were engaged in "science-type engineering." Many respondents found it hard to distinguish among scientists, "technicians" and engineers or, more generally, between engineering and science (see below). In sum, engineering is virtually an "invisible profession" to most Americans; they neither know much about it nor think about it often.

Hypothesis #2: Americans have only a dim sense of how engineering affects their lives. Most people take engineering for granted, without considering the profession's responsibility for technological innovation.

Consistent with the finding that those interviewed were largely unaware of what engineers do, most respondents did not spontaneously associate engineering with technological innovation or think that engineers are responsible for such change. Rather, the people interviewed had little sense about how engineering affects their daily lives. Respondents were most likely to say scientists, inventors or "technicians" were responsible for technological change. When asked about particular innovations, most tended to name professionals associated with particular technologies. For example, many said that advances in medicine, such as the CAT-scan and ultra-sound treatment, had been developed by doctors. Video-technology such as VCRs or cable television were often said to be developed by "technicians" (who were not identified further). Businessmen or "inventors" were felt to be responsible for workplace innovations such as the use of robotics. And scientists or inventors were usually said to be responsible for innovations with computers and the development of technologies related to the military or the exploration of space.

While a few people did say that engineers were responsible for the technological innovations listed above, most people interviewed spontaneously associated engineers with only a few technologies, notably with the design of automobiles and airplanes. This lack of understanding of the role of engineers should not be confused with views about the effects of technology (which is discussed more thoroughly in sections that follow). Respondents were keenly aware of technological innovation, felt its effects on their lives, and expected more and more change to occur faster and faster. Indeed, most respondents felt that such change could not be avoided in today's society. Yet respondents seemed to accept and be reconciled to the inevitability and effects of such change without understanding or even wondering how it occurs, and especially without considering the role of engineers.

Hypothesis #3: The profession is visible to most Americans only in cases of technological mishap, failure or breakdown.

Those interviewed did spontaneously tend to consider the role of engineering in one industry -- automobile manufacturing. A number of respondents said that American cars are "poorly engineered" compared to foreign models. Respondents' considered view was that industry engineers were not at fault for perceived shortcomings in automobile quality; rather, most felt that the real blame lay with management and workers. However, the fact that in this case respondents did consider the profession illustrates the tendency of the American people to be most aware of engineering when they think it is substandard.

More generally, respondents did not think about engineers and engineering as long as things were felt to run smoothly; these results suggest that under normal circumstances, the profession will probably continue to be "invisible" to most Americans. However, when something goes wrong, those interviewed did consider the role of engineering. Respondents' comments about Three Mile Island, weapons systems manufactured for the Pentagon, airplane crashes involving mechanical problems, the space shuttle tragedy, chemical industry accidents or highway collapses reinforce this interpretation. In considering each of those incidents and mishaps, the people interviewed were much more likely to consider spontaneously the role of engineering.

If respondents reactions are typical and it is true that Americans consider engineering only in cases of mishap, the profession may be in dangerously ambivalent circumstances: the American people want and expect the profession to meet a standard of excellence, and will take engineering for granted as long as that standard is met. Engineers will continue to receive little public acknowledgement or appreciation for innovation or accomplishment since these are felt to merely meet pre-existing expectations. It is only when the public's expectations are not met, and when products are believed to be inferior, poorly designed or even dangerous, that the profession ceases to be invisible.

Hypothesis #4: Americans have trouble distinguishing between engineering and science and see many similarities in the kinds of people in each profession.

Respondents' lack of awareness about who is responsible for technological change (as described in Hypothesis #2), echoes their confusion about the relationship between science and engineering. The distinction between the two fields was blurred in the minds of many. In fact, as one discussion progressed, some respondents said the distinction between the two fields became less clear. "The more we talked about it [the difference between science and engineering]," a Minneapolis woman said, "the less I was sure of the delineation."

Respondents often found it hard to describe the differences or appeared unsure of their answers, as if hoping for someone else to articulate the differences for them. In Boston, several respondents (including a student from Harvard University) said that engineering was merely one branch of science. "I think of engineering as a part of science," said one man to general agreement. The group was asked whether engineering was similar to biology, chemistry or physics -- that is, an area of specialization within the general field of science -- and many said that was exactly how they conceived of the difference.

When asked about the people in each profession, as distinct from the professions themselves, respondents also saw many similarities. Engineers and scientists were felt to have much in common. Specifically, both were said to be highly intelligent, naturally curious about how things worked, creative, and scrupulously honest; both scientists and engineers were also said to be precise, patient and careful, logical or mathematically-oriented, serious, intense, and devoted to their work or, in the words of a man from Minneapolis, "single-minded as far as their interests go . . ." However, many could draw a number of distinctions between members of the two professions, and many held a number of unflattering or negative views about "typical" or stereotypical engineers.

Hypothesis #5: Compared to the fields themselves, Americans are able to draw numerous distinctions between individuals in the professions of science and engineering.

Especially compared to the fields themselves, respondents were able to draw a number of distinctions between members of the two professions. For example, respondents tended to say that scientists work at an abstract level while an engineer's work is more concrete, or that scientists come up with ideas while engineers figure out how to implement a scientist's ideas and make them work. A Minneapolis man said, "A scientist will give an engineer an idea and an engineer will build on it. For example, a scientist develops a new material, and an engineer will find an application for it." A woman said, "A scientist has to be thinking all the time because he has to work with unknown facts, whereas the engineer designs [something] once the facts have been established." A man from Dallas said, "An engineer works with tangible things while a scientist works with research." A woman from Minneapolis said, "An "engineer deals with facts, while a scientist is always looking for new rules [about how the universe works]." Another man said that a "scientist will take a subject -- say a germ -- and find a cure [for a disease]; an engineer will build a table or a building and know structurally exactly what goes into it and price it out."

Several respondents said that scientists are more eccentric, think more about the long term and, in the words of one woman, "have more of the dreamer in them." On the other hand, people said engineers tend to be more practical, more down-to-earth, more likely to be "doers," more realistic especially in terms of financial matters, and more aware of others. A man from Dallas said, "The scientist lives with test tubes down in the basement in some university and the engineer lives in the real world outside." Asked which one they'd prefer a child of theirs to marry, most respondents said "an engineer" because engineers are more "touchable," or, in the words of a woman from Minneapolis, "easier to connect with." Another woman said, "A scientist is 'not there' in an emotional sense as he's often so preoccupied with his work and so impractical; it's difficult to communicate with someone who is 'not there.'"

Hypothesis #6: Americans have a number of negative views about stereotypical engineers.

Those interviewed were asked what they saw as negative or less flattering characteristics of typical or stereotypical engineers. In view of people's limited knowledge about the profession, it was surprising how many specifics respondents were able to provide. A number of those interviewed said their opinions were based on knowledge of particular engineers with whom they worked or knew socially, and a few had family members in the profession. However, several respondents took pains to emphasize that the engineers they knew did not fit the stereotype they proceeded to describe or endorse.

The most common negative about engineers involved what respondents called "the inability to communicate" with people outside the profession. In part, respondents said, engineers' difficulty in communicating is related to the nature of their work. Because their work is complex and technical, engineers find it hard to explain what they're doing to those who lack their technical expertise. Compounding this difficulty is what several people called "poor social skills." Some said that engineers are so mathematically-oriented that cannot express themselves clearly to others. "Maybe people can't understand what they [the engineers] are saying," one woman suggested. Additionally, since engineers were often said to be "loners" or "self-absorbed," or people with "a one track mind," many implied that engineers find it hard to empathize with others or to understand a nonengineer's interests, concerns, limitations or point of view. In sum, respondents felt that many engineers' difficulty in communicating with others is partly the result of the technical nature of their work and partly related to the personality of those attracted to the profession.

An additional negative involved the issue of engineers as managers. Several respondents said that engineers are similar to accountants in that they tend to be "rigid," to have "tunnel vision," or an inability to see the big picture." As a result, people said, engineers make poor managers. Many said that another reason why engineers are not good managers is because they are

"poor communicators." A few respondents said many engineers were "social misfits" with whom they would not want to talk at a party or be trapped with on an elevator because engineers are so wrapped up in their work and difficult to communicate with.

Finally, a small number of respondents considered engineers to be "alarmists" or "overreactors." In the context of the Challenger accident, for example (which is discussed in detail in Hypothesis #12, below), a few respondents said they could understand why NASA officials and the management of the shuttle's contractors might not listen to the engineers' warnings. One respondent, a former fighter pilot, described how the engineers, mechanics and technical people who worked on his aircraft frequently told him that his plane was not fit to fly. "I took what they said with a grain of salt," he said. "It was their job to be overly cautious, but I had missions to fly and pressure [from my commanders] to do my job. So I guess I can understand why those people [at NASA, etc..] might not have taken everything they [the engineers] said at face value either." In this regard, however, we should emphasize that respondents did not want engineers to change. With unanimity, everyone in the group, including the former pilot, felt that engineers should be overly cautious, and felt that extreme precision and attention to detail an absolutely an essential part of their job. It was in the context of an engineer's personality -- not his professional responsibility -- that this stereotypical characteristic of "alarmism" was felt to be occasionally excessive and a factor to keep in mind when listening to an engineer's assessments.

Hypothesis #7: In spite of these negative stereotypes, most Americans see engineering as a desirable career. People feel that it is an esteemed profession with a good salary and good advancement opportunities.

In spite of respondents' lack of knowledge about what engineers do and in spite of the negative stereotypes described above, most of the college educated Americans interviewed had definite ideas about the status of the profession and regarded engineering highly, about on a par with medicine and law. Respondents said that engineering was a field they would happily see their children or loved ones enter because, in their view, it is prestigious: an engineer's work is interesting and rewarding, engineers enjoy a good deal of independence, and the profession offers good career opportunities in both the number of available jobs and chances for advancement. One woman said that engineering "is where the jobs are." The field was also felt to be wide open to minority group members and women. "It takes brain power [to be an engineer]," said a Dallas man. "So it doesn't make any difference [if an engineer is a woman or a minority group member]."

Most respondents also had fairly accurate ideas about engineers' salary, at both the entry level and after being established. When asked what the starting salary for an engineer is, respondents in Dallas and Detroit guessed about $25,000 -- a figure quite close to the average starting salary recently published. When asked the salary of an engineer who is established in the profession, respondents guessed within a range quite close to the salary data provided to the Public Agenda by the National Academy.

A few respondents said that engineering was a field that would prefer a loved one not to enter, especially after discussing the negative stereotypes about member of the profession. But for the overwhelming majority of respondents, engineering was considered to be a highly desirable career for their children or loved ones, even after lengthy discussions about the negative stereotypes of engineers.

Hypothesis #8: Except for engineers in the automobile industry and with the possible exception of the Japanese, U.S. engineers are felt to be the best in the world. Problems with industrial competitiveness are felt to be caused by management practices and employee attitudes, not poor engineering.

Respondents in several sessions were asked to rate American engineering and American engineers against their European, West German, Soviet and Japanese counterparts in a discussion about factors affecting U.S. industrial competitiveness. With the occasional exception of the Japanese, American engineers were consistently said to be the world's best. Solid majorities rated American engineering as vastly superior in every respect, including education, training, and performance in all areas with the exception of automobile design (which is discussed at length in Hypothesis #9 below). Respondents named a number of colleges and universities that specialize in training engineers, and said that the quality of education at these schools is as good or better than at any institution in the world. In comparisons with Japan, most respondents felt that U.S. engineering was superior, but many also said that the U.S. had only a slight edge. A minority felt that Japanese engineering was generally better than engineering in the U.S.

In this context, it is important to note that respondents were keenly aware of the problem of U.S. industrial competitiveness. But most of the people interviewed felt that the root cause of these problems was either management practices, ("they think too much in the short-term") or labor ("American workers don't care enough about what they do"). Virtually no one interviewed felt that inferior or inadequate engineering was responsible for this country's difficulties in competing internationally.

Hypothesis #9: The belief that American-made autos are "poorly engineered" has undermined public confidence in auto engineering, even though most people say auto industry engineers themselves are not responsible for the problem. In fact, this perception has the potential to undermine Americans' confidence in the entire profession.

In addition to Japanese engineers, there was one conspicuous exception to the generally excellent rating respondents gave U.S. engineering. Most of those interviewed tended to rate engineers in the automobile industry quite differently than others in the profession. In Denver and, to a lesser extent, Detroit, respondents said that the performance of auto industry engineers was inferior to their Japanese and European counterparts, and far behind American engineers in other fields. However, follow-up questioning revealed that much of respondents' sentiments about automobile engineering actually reflected their views about management and workmanship rather than the quality of the engineering itself. In respondents' minds, auto industry executives were more short-sighted than their Japanese counterparts, and willing to cut corners in quality or ignore design problems that engineers brought to their attention. "They [management] will take shortcuts," said a Minneapolis woman. Many also said that U.S. auto workers are not as careful or as quality conscious as auto workers in Japan. "It's the way the cars are built," said a man from Detroit. "The Japanese are more careful about what they're doing." Finally, a few mentioned manufacturing innovations such as more use of robotics by the Japanese.

In sum, while probing revealed that much of the low rating people gave auto industry engineers actually reflected their thinking about management and workmanship, the initial difference in respondents' assessment of auto industry engineers and all others was dramatic and pronounced. Further, while their considered judgments were considerably different, many of the people interviewed continued to feel, even after lengthy discussion about management and workmanship in the industry, that auto industry engineering was not as good as engineering in other fields. Indeed, sentiment about automobile

engineering was so striking that respondents in one session (Denver) gave a completely different answer to a comparison of U.S. engineering to engineering in other countries when automobile industry engineering was taken into consideration and when it was excluded. When it was included, people in Denver rated U.S. engineering as "average" compared to engineering in Europe and Japan. But when auto industry engineers were excluded, they answered the same question by saying that American engineering was vastly superior to engineering in any other country. In sum, views about the poor quality of American-made automobiles seems to have created a "negative halo" which affected respondents views about auto industry engineers and about the entire profession, and in spite of the fact that the engineers themselves were not felt to be responsible.

Hypothesis #10: Americans believe that engineers have an unusually high degree of integrity.

One of the most frequent comments respondents made about members of the profession was that engineers have an unusually strong sense of integrity. In part, these views seemed to be derived from respondents' perceptions about the nature of an engineer's work. Since engineering was seen as a field where answers are "exact" mathematical calculations and therefore either right or wrong, respondents felt that engineers were reliable reporters of their work. In this regard, engineers were felt to be more like accountants than, for example, attorneys whose professional opinions are often matters of judgment.

Additionally, respondents implied that engineering's professional standards served to reinforce an individual engineer's sense of integrity. Since the profession demands accuracy and because an engineer's work and professional standing is judged according to the accuracy of his calculations, engineers are trained to report their conclusions, regardless of any other consideration. Finally, respondents felt that those who were attracted to the profession probably had exceptional integrity to begin with. And engineers were also thought to be highly intelligent, careful, serious, hardworking professionals -- personality characteristics that reinforce a strong sense of integrity in respondents' minds.

In sum then, respondents saw engineers as members of a nearly incorruptible professional elite who could be relied on to describe accurately their work to those ultimately responsible for decisionmaking. Respondents felt that such reports would be made regardless of any other consideration, in part because an engineer's professional responsibility required as much, and in part because of the temperament and personality of those attracted to the profession in the first place.

Hypothesis #11: Americans do not tend to blame engineers for technological accidents, mishaps or disasters.

Respondents were asked about a number of events that have occurred over the past several years, including the accident at Three Mile Island, the tragedy at Bhopal, auto safety problems such as with the Pinto fuel tank explosions, airplane crashes such as the one at O'Hare where an engine fell off a jet just after takeoff, and highway or bridge collapses. In general, respondents did not tend to blame the engineers involved for these problems -- a result suggesting that, at present, there is a deep reservoir of public confidence in the members of the profession.

Even in the automobile industry, where many said "poor engineering" is a chronic problem, most respondents said that the fault lay with businessmen or managers who make shortsighted decisions, interfere with the engineers' ability to do their jobs, and ignore safety problems brought to their attention. "The engineers probably told them [management] about it [the safety hazard of the Pinto gas tanks]," one woman said. "But they [management] ignored it; they wanted to sweep it under the rug. They'll ignore whatever they think they can get away with [i.e., expensive to repair safety-related problems or defects]. That's one way they improve the [company's] bottom line."

Other mishaps such as the airplane crash at O'Hare were blamed on "poor maintenance" rather than engineering or design. In that regard, respondents also tended to feel that the maintenance personnel themselves were probably not responsible. A Denver man suggested, to general agreement among the rest of the group, that American companies often cutback maintenance as much as possible in order to hold down costs. "The general design of the aircraft is pretty good," she said. "But there's such a push to keep the aircraft in service and not take account of the maintenance required." In the cases of Three Mile Island and Bhopal, management shortcuts, human error or what many called "design flaws" were felt to be the reason for the disasters. A Minneapolis man said, "I don't think the engineers were involved [in causing the incident at Bhopal]. It was misuse, human error caused by the operators."

Importantly, respondents in one group (Boston) were asked about the accident in Chernobyl which occurred several days before the session. Even in that case, Soviet engineers were not felt to be responsible for the accident. Rather, respondents offered a number of reasons for the tragedy in addition to those that they felt applied to disasters in the United States. Some felt that Soviet officials had cutback safety standards in an effort to cut costs and save money. And several said that the Soviet system is closed to independent critics such as the news media, environmentalist and citizen advocates such as Ralph Nader. In the U.S., they said, these voices would raise tough questions about design and operations that, because of pressure from public opinion, authorities would be forced to answer. But in the Soviet Union, there are no such independent critics and no independent public opinion with which authorities must deal. "If an auto industry was not intending to add a safety feature," one woman said, "there's a Ralph Nader who says 'You will add it.' Whereas in Russia, if they're not intending to add a safety feature, they don't have the [independent] organization that will say 'Do it.'"

Absent such voices, respondents suggested that nonexperts have a freer hand to disregard or downplay the concerns of engineers and scientists and other experts who built the reactor and were responsible for running it safely. "The question is not the scientists, their scientists are equally good. In the Soviet Union, 40 people determine the entire nuclear policy. It's not surprising that the situation [i.e., the accident] was handled differently under those conditions."

Also important is what these attitudes suggest in a more general sense: since the groups' views were presumably based on surmise, we can infer that these sentiments reflect the degree of respondents' confidence in U.S. engineers at least as much as it describes the nature of the Soviet bureaucracy. That is, since respondents did not know who is responsible for maintaining safety at Soviet nuclear power plants, we can reasonably infer that their conclusions reflect that with which they are familiar -- i.e., the general level of competence of engineers in the United States.

Hypothesis #12: More specifically, Americans feel that the investigation into the Challenger accident showed that the engineers involved were not at all to blame.

While most of the college educated citizens interviewed were not thoroughly familiar with every aspect of the Rogers Committee investigation into the events that occurred before the launch of Challenger, most were sufficiently aware of the proceedings to offer a number of opinions. Respondents generally felt that the engineers who testified before the Rogers panel had acquitted themselves honorably and had conclusively shown that they were not to blame for the tragedy. "They [the engineers] were the experts, and their thinking before the launch should have carried more weight," a Dallas man said. "The bureaucrats should have paid more attention to the engineers," a woman said. Several respondents suggested that the engineers were the only professionals who gave top priority to the safety of the crew. "I was curious why they [the engineers] weren't taken more seriously by the shuttle officials," a woman from Minneapolis said. "It seemed like nobody was listening to anybody," said another woman. "There was no leadership."

Respondents did not always agree about who was to blame for the decision to launch, though everyone agreed a mistake had been made and that the explosion was not simply a case of an accident. Several suggested that NASA officials were responsible. "It's part of the record if an engineer writes a report and passes it on," said a man from Minneapolis. "Whoever didn't check it [the record] out thoroughly, the project manager or whoever, is to blame." A man from Detroit suggested that public opinion pressure was a factor. "Public opinion was beginning to think that NASA was joke because they scrubbed so many missions," he said. Others suspected that political pressures were at least partly responsible. "I blame the Reagan administration," said one man. "He [the President] wanted to show America and the Russians that we were going to put the shuttle up. Wasn't he [the President] going to be on television that night?" A man from Dallas agreed and said, "I think there was subtle pressure coming down from Washington saying 'fly.'"

In-depth questioning revealed that some people in the groups thought the engineers involved should have been more forceful in expressing their concerns. "Assuming they knew what the problem was," a Dallas man said, "they [the engineers] should have had enough courage to speak up." A man from Detroit said, "The engineers that were concerned about safety didn't really press their point as much as they could have. Due to the pressure against holding up the launch, they went along even knowing full well that perhaps it wasn't as safe as it might be." A woman from Boston said, "It's typical of a lot of professions to hedge your bets. To say: 'It may be sunny until it starts to rain.' Maybe that's what they [the engineers] were really doing (and that is why they did not protest more loudly)." Most respondents, however, seemed to feel that the engineers had done all they could have been reasonably expected to do. "I wonder if the engineers really had the power to stop it [the flight]," said one woman.

Hypothesis #13: Americans feel that engineers and scientists should be more involved in making decisions about the development and use of new technology. However, people do not feel that experts should have the final say.

In two sessions, the college educated citizens interviewed were asked to pretend that they were a congressional committee that had to decide whether to approve the development and use of a controversial new technology. In that regard, they were asked whom they would like to hear testify before making a decision about whether this new technology could be safely developed and introduced. With virtual unanimity, respondents felt that they (and by implication, members of Congress) should hear from a wide variety of experts with different points of view, and particularly from experts who do not have a vested interest in the subject.

A Boston woman said, to general agreement among others in the group, that in her pretend role as a member of Congress she "wanted to hear from experts who have nothing at stake [in terms of the particular project], who have a track record of doing good for people." A woman from Denver wanted to hear from the most qualified experts and advisors available and suggested that the quality of the advice she received would determine what her decision would be. "If you have bad advisors," she said, "then you will make bad decisions." Several respondents also said that top management in both the government and American industry does not hear directly from engineers, scientists and other technical experts, and that they should receive such information more often and more directly. "We (the imaginary congressional committee) need to hear from experts such as engineers and scientists," said a Denver man. "In fact, I think every corporation should have at least one engineer on its board [of directors]."

Importantly, however, those interviewed unanimously agreed that the final decision about whether to develop or use new technology should not be left to any group of experts, no matter how well qualified or how independent. Rather, those interviewed felt that in a democratic society, it should be their

responsibility (thinking of themselves as members of Congress) and, implicitly, the responsibility of nonexperts, to make the final decisions. "I want to listen to all their opinions," a woman from Boston said, "but I want to make the final decision." Another said that she and the others "had been elected (to the Congress and were members of the imaginary committee) because we are experts in being good listeners and have good judgment. What we've been elected to do is to take information, synthesize it, and make the final decisions ourselves."

A man from Boston expressed his willingness to give scientists, engineers and other experts "veto power" over technological development or use if issues of public safety were involved. He also felt that the engineers should have had that authority in terms of the decision to launch Challenger. "The experts must have veto power," he said. "They must have the ability to stop something that they know will explode in our faces." Others felt that the ability to stop a project was a separate question; while they did not rule out the possibility of giving experts such authority, their strongest feelings were about the other aspects of the question -- about the need for decisionmakers to hear from a variety of experts, at least some of whom are independent, and the fact that nonexperts should be responsible for making the final decision about whether to develop and use a new technology.

IV. HYPOTHESES: AMERICANS' AND LEGISLATIVE LEADERS' VIEWS ABOUT TECHNOLOGY

Hypothesis #14: Americans have great faith in technology, and feel that it has led to far more good than harm. Nonetheless, many worry about the rate of change.

Respondents expressed a great deal of confidence in technology and felt that it had led to far more good than harm. With virtual unanimity, they said the U.S. must continue to develop new technology, that technology means progress and an increased standard of living. In fact, peoples' comments suggest that many saw technology as virtually synonymous with progress. Respondents cited labor saving devices such as computers and robotics, medical technologies such as CAT-scanners, ultra-sound treatment, artificial hearts and transplants, and technologies, such as VCRs, related to entertainment as some of the most recent examples of technological progress. A Dallas man said, "The amount of data that can be processed with a tremendous degree of accuracy is amazing." A man in Boston said "Some little kid can poke into a computer to do something in a day that it would take me a week to do." A Boston woman said "Technology gives people more leisure time because it does routine tasks very quickly."

Most respondents felt that technology was changing their lives quickly and dramatically. Several seemed awed by it all and concerned about the rate of change. "It's exciting that things are changing so fast," said a Denver woman. "But it's all so fast." A woman in Boston said, "I remember my grandparents saying: 'This color TV can't be good' or 'What will happen with this [technological change]?' The faster we go, the faster we move, the farther we get along. The more computers we make, the more it's going to be possible to solve problems that are unsolvable today." A number of respondents marveled at childrens' ability to learn how to use computers and other technologies. "I'm amazed at how good kids are [with computers]," said a Denver woman. "They sit down and figure it out." Another said, "I can't imagine what it'll be like when they [today's technologically-literate children] grow up."

Hypothesis #15: Americans are also concerned about technology leading to job loss, especially for older workers.

One perceived negative effect of technological development cited by a number of respondents involved the loss of jobs in particular industries. Several respondents talked about job loss in industries such as automobile manufacturing because of the use of robots. A man from Denver who worked in a recording studio described what he saw as an imminent effect of another technological innovation. "There are machines that can duplicate the sound of any instrument," he said. "In a recording studio, it's expensive to hire musicians to record with; it's would be a lot cheaper to have one person (the one operating the machine) doing the job of three or four musicians. I think it [this particular technology] is going to take away a lot of jobs."

Other respondents felt that job loss due to technological innovation was just beginning. "I don't think they are replacing that many people with it yet," said a woman from Denver. "But it's coming; and when it does, it's really going to hit people hard." A computer programmer for the telephone company described how his job was eliminated. "Twice, the job I had was scratched, replaced by a computer," he said. " I'm an expert in this stuff [the use of computers]. But I constantly have to learn new things in order to keep a job."

At the same time, many respondents seemed to feel that concern about technological job loss had to balanced against the jobs that technology created. "There are fewer jobs being lost than there are jobs being created [by new technology]," said a woman from Denver. However, several respondents implied that younger workers would find it easier to adjust and that older worked were particularly vulnerable, regardless of the new jobs created. "It [computers and other technology] is all so confusing to me," an older woman said. A middle-aged man from Boston said, "Young people catch on very easily, but for people my age, it [new technology] is very hard to understand and use."

Hypothesis #16: Americans' faith in technology is neither blind nor without qualification: most feel that technology has created a number of serious problems.

Respondents cited numerous drawbacks to technological development. Many expressed concern about depersonalization or the loss of privacy. A Denver resident said, "Computers allow people to find out too much about you much too easily." A woman worried about the long term effects. "I think eventually they [computers] will do more than we would like them to do," she said. "It starts out as an experiment: more and more people will try paying for groceries in a supermarket by drawing directly from their bank account [through electronic funds transfer]. Then it'll turn into a 'Big Brother-type thing' where everything about you is known." A man from Boston said people were starting to talk like computers, in "computerese" or "forms;" instead of people controlling computers, he said, the computers were controlling human behavior and changing the way people relate to each other. "People are losing contact; they aren't 'people' anymore," he said. "We're becoming like our machines."

A Denver woman described how a long ago computer error continued to haunt her son. She said her son had the same name as someone who had been in a traffic accident years earlier, and that his name had been incorrectly entered as the guilty driver. His insurance payments, his credit rating, and his driving record had all been affected, she said. While corrections were made, her son continued to be plagued by the misinformation. "Once it's on the computer, forget it," she said. "It's there for life."

Yet while saying that technology creates problems, several respondents suggested that such problems were caused by people and how they use technology, not with technology itself. "Computers don't make mistakes," one man said, "people do." Another said, "The problem is how we use it [technology]. Will we blow ourselves up [with nuclear weapons] or cure disease and improve people's standard of living around the world. It's up to us."

Hypothesis #17: The key to solving many of these problems caused by technology is, in Americans' view, to develop more technology -- but with additional safeguards.

A man from Detroit suggested, to general agreement among members of the group, that the way to solve problems created by technology was to develop more technology. "You create problems, you find ways to solve them," he said. "Technology has harmed our environment with acid rain, pollution, and so on. But we can overcome them [these problems] with more technology." In other sessions as well, respondents felt that many of the problems created by technology could best be solved by developing more technology.

At the same time, most of the people interviewed agreed that especially in certain areas, technological development should proceed only if greater safety precautions are taken. More specifically, no one in the Boston group (the only session held after the accident at Chernobyl) felt that the accident changed their mind about the wisdom of using nuclear power: those in favor continued to be in favor. But the group did feel that the accident demonstrated the need for improving safety measures and precautions regarding the use of nuclear power. "You are always going to have problems with things like this at first," one man said. "When they first used anesthesia, people died. But that doesn't mean we shouldn't take more precautions." A woman said, "We need to improve on [how we do] things. But I don't think you should necessarily stop doing something (even if there is a serious accident)." Another woman said, "If they are going to use it [nuclear power] as an energy source, they they are going to have to learn how to control it before they ruin things. There needs to be more safety measures taken.

These attitudes are consistent with the public opinion results reported in phase one of the project -- the analysis of public opinion data regarding the explosion of the space shuttle, Challenger.* In the surveys analyzed in that report, large majorities of Americans did not feel that the Challenger tragedy meant that we should stop or even slow down the space program. To the contrary, most Americans surveyed said we should continue to go forward with the space effort. On balance then, neither tragedy turned around public

opinion about the technology involved. Instead, the comments of those interviewed suggest that Americans have a fairly clear, measured understanding of the risks and benefits of technological development, and that they consider both when making assessments about technological innovations. The results also suggest that the American people believe that accidents and even tragedies are an inevitable part of the price of progress, and that we should therefore take every precaution to minimize the risks and dangers.

* For a detailed analysis of public opinion after the explosion of the Challenger, see: "Public Attitudes Toward Engineering and Technology: An analysis of existing survey data for the National Academy of Engineering," by Mary Komarnicki and John Doble, The Public Agenda Foundation, February 1986.

Hypothesis #18: Especially when expert opinion is divided, legislative leaders are concerned about how to regulate and decide about the development or use of expensive, complex technology that may pose risks to society.

The legislative leaders interviewed expressed concern about the difficulty of deciding about complex technical issues such as SDI or how to regulate the use of certain potentially dangerous technologies such as biotechnical research or the disposal of nuclear wastes, especially when expert opinion is split. One leader said, "Let me only say that on SDI research, where the scientific community is so badly split [about the feasibility of the system], that Congress doesn't have a 'North Pole' to look to -- this is one of our greatest problems." Another leader described the difficulties facing members as they try to decide about technologies that present potential dangers. "On something like genetic engineering," he said, "it is very difficult [to write reasonable regulations that will protect the public while allowing research to continue]. There's no independent way to evaluate that [type of research]; it's really 'seat of the pants' reasoning."

The public's view that Congress should hear more from 'independent experts' was felt to be unrealistic. "There's no such thing as an 'independent' expert," one leader said. "Everyone, even ourselves in presenting issues to our bosses, tends to shape or present things in certain ways [in order to get a particular decision]." Another said, "Instead of an 'unbiased' expert, what you usually find are two biased opinions, and you try to weigh each side." A third said, "I think Congressmen feel the same frustration [that respondents' expressed when playing the role of a congressional committee]. Sometimes there just isn't an answer out there, there isn't one person a member can call up and ask. Eventually, they [the members of Congress] are persuaded that's true, but they still want it not to be." Finally, and perhaps of key importance, several leaders implied that when expert opinion is split, members of Congress are more likely to disregard expert opinion altogether and look to other factors, such as the wishes of and impact on their constituency, when deciding about difficult issues related to the development or use of new technology.

Hypothesis #19: Contrary to leaders' assumptions, Americans define "new technology" in terms of computers, VCRs, and other work or household-related innovations, rather than as the technologies that are subjects of controversy.

When asked to detail the "new technologies" that have had a major impact on society and on themselves, the college educated citizens interviewed for the project most frequently mentioned computers, VCRs, microwave ovens and other technologies that directly affect their lives. The second most frequently named technologies were medical advances such as artificial hearts, CAT scanners, and the use of robots in the workplace. Respondents did not tend to name nuclear weapons, SDI or other technologies related to national defense, DNA research, nuclear power or other energy-related technologies.

This result may be particularly important if the discussion conducted with legislative assistants reflects the general sentiment on Capitol Hill. Several of those leaders suggested that national leaders and legislators assume that when the American people think of "new technology" they automatically think of nuclear weapons, the Strategic Defense Initiative, and controversial biotechnology such as DNA research. "I think that the public doesn't see VCRs as 'technology,'" said one legislative assistant. "They see them [VCRs] as a product, a means toward an end."

But in fact, the citizens interviewed for the project had to be prompted before they considered the issue the way that leaders assumed they did. For example, one group was asked to list the dangers and negative effects of technology. While the group quickly came up with a long list, not one respondent mentioned DNA research, any defense-related technology, chemical or biological weapons, or the threat of nuclear annihilation. Only after the moderator suggested that the group had overlooked the greatest dangers did respondents shift to the broader frame of reference and discuss the issue in those terms.

Leaders' apparent misunderstanding of what the term "new technology" means to most Americans may lead them to incorrectly assess much public opinion in this area. Based on the assumption that "technology" did not mean VCRs, etc., several legislative leaders drew sweeping conclusions about how Americans feel about technology in a general sense. Some said, for example, that the public is either "neutral" or "conservative" about the introduction of new technology -- a response at odds with the views of the citizens interviewed. "Americans are conservative in their approach to technology," one legislative assistant said. "In Japan, if something doesn't work right away, they'll try again. But it's part of our culture that we don't like to try things, we're just not willing to accept failure (or risks)."

In sum, key decisionmakers may incorrectly understand what Americans mean when they use the term "new technology;" and this misunderstanding may lead them to misinterpret a good deal of public opinion about the issue in both a general sense and in relation to particular technologies. In particular, leaders may underestimate Americans' willingness to develop new, even potentially dangerous technology, and their understanding of and concerns about potential risks and dangers.

Hypothesis #21: Legislative leaders worry about America's technological competitiveness and overall technological literacy. While the public feels that U.S. engineering is the world's best, leaders express concern about policies affecting the future.

The citizens interviewed felt that U.S. engineers were, generally speaking, the best in the world, that their education and training was superior, and that their overall level of competence was unmatched, except perhaps by the Japanese. Without disputing that interpretation, a number of the legislative leaders interviewed expressed concern about U.S. technological competitiveness in the future because of what they felt were short-sighted policies today.

"I think we (the United States) have been very effective in producing tremendous basic research," one leader said. "But we're not as good as the Japanese in translating them [basic research ideas] from the bench to the production line." The same leader expressed concern about American universities. "Another concern is the universities -- how to keep the infrastructure healthy so that chemists and engineers and others who need sophisticated labs and a good deal of support will stay there." One legislative assistant suggested that the greatest problem is not in the universities. "We're not getting them [qualified science and math teachers] into the schools," he said. "We're losing them in junior high school and high school."

Importantly, the citizens interviewed expressed little interest in learning about technology -- a result that reinforces leaders' concern. Most said that they do not seek out information on new technological developments either from the newspaper or television. While some said they occasionally do watch a television special about new technology, they also said it usually happens by chance, when a program catches their attention as they are switching channels, for example. And while some said that material about technology was difficult to understand or they didn't have the time to watch such shows or read the newspaper, many suggested there was another reason for their lack of attentiveness. "It's all changing so fast," was a comment made by many

people, implying that they and other adults had trouble digesting or becoming acclimated to all the rapid social changes brought on by technology. In effect, it would seem as if their difficulty in digesting and adapting to the effects of technological innovation was as much a factor in their decision not to pay attention as the difficulty of the material in an intellectual sense. At the same time, a number of respondents commented that their children often watch television shows of this type -- and certainly much more often than they do themselves. "My son will watch anything to do with computers," one woman said. Indeed, there was a general feeling that children are much more attracted to these topics, that they learn about it more easily, and are more comfortable with the entire subject.

Hypothesis #22: Legislative leaders feel that increasing the public's level of 'technological literacy' would have a significant impact on the Congress.

Most of the legislative leaders interviewed felt that, for the most part, Americans' views about the development and use of new technology are balanced and reasonable. But many nevertheless said that there are segments of the public who, while not particularly knowledgeable, have a disproportionate effect on Congressional decisionmaking. One leader cited as an example constituents who oppose medical research on animals. "We get lots of mail on this issue, pro and con, and not very much that's 'pro.' About the only pro mail we get says we should use people instead of animals. This constituency may not be very technological literate, but they're very well organized and that has an impact."

Several leaders suggested that less well educated Americans were the constituency most in need of increased knowledge. However, the more general view was that increasing the public's technological literacy on all levels would increase technological literacy in the Congress. "They [members of Congress] aren't experts either," one leader said. "Congress reflects what the public wants and what the public is like. Members of Congress come from the general public. So if the public were more knowledgeable about technological issues, members would become more knowledgeable too -- either to get elected in the first place, or to communicate with their constituency and get re-elected."

A minority expressed a totally different view. They said that a more technologically literate public would adversely affect congressional decisionmaking, and possibly even paralyze some debates. "A more educated public will be more divided," one leader said. "And instead of better decisions, we're likely to have fewer of them."

V. METHODOLOGY

Focus Groups with the General Public: Five discussion groups, each lasting about two hours, were conducted across the country with cross sections of about a dozen college educated Americans. The decision to interview only those with at least some college education was made by the Academy after consultation with the Public Agenda as this group was seen as the potential target of any Academy programs or endeavors with the public. Each group was stratified on the basis of age, sex and race. Since the research was designed to investigate the views of nonexperts, no scientists, members of the engineering profession or members of the nuclear power or space industries were allowed to be respondents; additionally no one was a respondent who had participated in a focus group within the last year. Questions and line of inquiry were developed by John Doble and Mary Komarnicki of the Public Agenda in close consultation with Bradley Ziff of the National Academy. All groups were conducted by Mr. Doble. Each session was tape recorded and analyzed by Mr. Doble and Ms. Komarnicki, with the assistance from Judith Kallick of the Public Agenda.

The groups were conducted in the following cities:

Dallas, Texas on March 31, 1986
Detroit, Michigan on April 1, 1986
Minneapolis, Minnesota on April 17, 1986
Denver, Colorado on April 24, 1986
Boston, Mass. on May 1, 1986

Leadership Focus Group: In addition to the sessions with the general public, the Public Agenda conducted one discussion with a bipartisan group of nine ranking legislative and committee aides from both the U.S. Senate and House of Representatives. These leaders were chosen because of their involvement on committees dealing with science, technology or other matters related to engineering. That session, on the evening of May 15, 1986, was designed to investigate leaders' reactions and responses to some of the material gleaned from the interviews with the general public. The session was held at the Academy, and jointly conducted by Mr. Doble and Ms. Komarnicki.